a9 means for further ~~amplifying~~ said signal within an Erbium-doped fiber amplifier.

DRAWINGS

A corrected version of Fig. 3 is submitted herewith with the corrections marked in red ink.

REMARKS

Claims 1-27 have been examined and rejected. The present response amends claims 2, 4-5, 9-12, 15-16, 19-20, 24-27 and cancels claims 1, 3, 8, 13, 14, 18, 23. Accordingly, claims 2, 4-7, 9-12, 15-17, 19-22, 24-27 remain pending. Reconsideration and allowance of all pending claims are respectfully requested.

Objection to the Drawings

The drawings have been objected to due to the labeling of the Y-axis of Fig. 3. In response, a proposed corrected Fig. 3 has been submitted where the Y-axis title has been changed to read "cross-gain modulation" as suggested by the examiner. The objection is therefore overcome and its withdrawal is respectfully requested.

Objection to the Specification

The specification has been objected to on the grounds that reference to the article authored by P. Hansen, et al., is improper because the article contains "essential" subject matter. It is contended that the information disclosed in this article is essential to make and use the invention of claim 8.

It is respectfully submitted that the contents of the Hansen et al. reference are not actually essential to enable claim 8. However, solely for the purpose for expediting prosecution, claim 8 is being cancelled without prejudice, mooting this rejection.

Objection to Claims 11 and 16

Claims 11 and 16 have been objected to under 37 CFR 1.75(c) as being of improper dependent form for failing to further limit the subject matter of the previous claim. This

objection is respectfully traversed. Independent claims 4 and 14 recite "a fiber" but do so inferentially. The fiber need not form a part of the apparatus that is defined by these independent claims. The objected to claims 11 and 16 include narrowing limitations in that they require that the fiber, cited in the parent claims only inferentially, actually be included as part of the defined apparatus. The objection is therefore overcome and should be withdrawn.

Rejection of Claims 5-6, 20-21, and 25-26 Under 35 USC 112, First Paragraph

Claims 5-6, 20-21, 25-26 have been rejected under 35 USC 112, first paragraph, on the grounds that they are not fully enabled by the specification as filed. It is respectfully submitted that one of skill in the art could in fact practice the invention as defined by the scope of these rejected claims. However, to expedite prosecution, the application is being amended to directly incorporate text that had previously been included in the provisional application from which the present application claims priority. This provisional application had been incorporated by reference in the present application. Text substantially similar to this provisional application is being added as an appendix to the present application. A supporting declaration is filed herewith.

In the rejection, the applicant asserts that Fig. 2 and the text at pages 9-11 teach how to practice only one particular embodiment of the invention for a particular combination of parameters and a particular type of fiber. In response, the applicants have amended the text on page 9 to refer to the new appendix as a source for the equations and calculations underlying the plot of Fig. 2. By using the analysis and equations in the appendix, one of ordinary skill in the art can derive the solid contour of Fig. 2 and can modify this contour to take into account changes in parameters or changes in the type of fiber. This rejection is therefore overcome.

Rejection of Claims 8 and 14 under 35 USC 112, First Paragraph

Claims 8 and 14 have been rejected under 35 USC 112, first paragraph as being non-enabled by the specification. This contention is respectfully traversed. However, to expedite prosecution, these claims have been cancelled without prejudice, mooting their rejection.

Rejection of Claims 2, 4, 15, 19, and 24 under 35 USC 112, Second Paragraph

Claims 2, 4, 15, 19, and 24 have been rejected under 35 USC 112, second paragraph as being indefinite. The rejection contends that the term "given" is unclear. It is respectfully submitted that this term is in fact clear. However, to expedite prosecution, these claims have been amended to substitute "for a selected" for "given a". Withdrawal of this rejection is respectfully requested.

Rejection of Claims 11 and 16 under 35 USC 112, Second Paragraph

Claims 11 and 16 have been rejected under 35 USC 112, second paragraph as being indefinite. The rejection asserts there is insufficient antecedent basis for the term "said fiber". This contention is respectfully traversed. As indicated in the response to the objection to these claims, the term "said fiber" refers to the "a fiber" limitation in the parent claims. This rejection is therefore overcome.

Rejection of Claims 1-2 under 35 USC 102(e)

Claims 1-2 have been rejected under 35 USC 102(e) as being anticipated by U.S. Patent No. 6,384,963 issued to Ackerman, et al. (hereinafter Ackerman). To expedite prosecution, claim 1 has been cancelled and its limitations imported into previously dependent claim 2. Claim 2 is submitted to be allowable over the art of record. The Ackerman patent fails to disclose or suggest any mention of beneficial four-wave mixing suppression characteristics as required by claim 2, as amended. Claim 2 is therefore allowable over the art of record and the rejection should be withdrawn.

Rejection of Claims 3-4, 11-13, 15-19, 22-24, and 27 under 35 USC 103(a)

Claims 3-4, 11-13, 15-19, 22-24, and 27 have been rejected under 35 USC 103(a) as being obvious over U.S. Patent No. 6,356,383 issued to Cornwell, Jr. et al. (hereinafter "Cornwell"). It is respectfully submitted that the pending ones of the rejected claims are patentable over the art of record and that this rejection should be withdrawn.

Claim 3, 13, 18 and 23 have been cancelled to expedite prosecution. The cancellation of these claims moots their rejection.

Claims 4, 15, 19, and 24 have been amended to incorporate the limitations of the cancelled claims 3, 13, 18, and 23, respectively. These claims recite that the use of co-

propagating optical pump energy as opposed to only counter-propagating optical pump energy as having beneficial characteristics. For example, claim 4 recites:

> "either 1) for a selected signal to noise ratio, there is a greater four-wave mixing product suppression levels than would be achieved using only said second optical pump energy source to obtain said gain level or 2) for a selected four-wave mixing product suppression level, there is a higher signal to noise ratio than would be achieved using only said second optical pump energy source to obtain said total gain level."

By contrast, neither the Cornwell nor the Ackerman references disclose or suggest the recited beneficial four-wave mixing characteristics. Furthermore, Applicants respectfully traverse the rejection's contention that it would have been obvious to modify the Cornwell reference to have a better FWM product suppression level because such is well known in the art to occur when co-pumping a Raman amplifier so as to achieve a 4 dB gain or greater. This effect is respectfully submitted to not be "well known" and the Examiner has supplied no reference to support this contention and cannot rely upon Applicants' own disclosure. Claims 4, 15, 19 and 24 are therefore allowable over the art of record.

Claims 11, 12, 16, 17, 22, and 27 are allowable for at least the reason of their dependence from their parent claims.

Rejection of Claims 7, 9, and 10 Under 35 USC 103(a)

Claims 7, 9, and 10 have been rejected as being obvious over Cornwell in view of Ackerman and Aoki, "Properties of Fiber Raman Amplifiers and their Applicability to Digital Optical Communications Systems" IEEE Journal of Lightwave Technology, Vol. 6, No. 7, July 1988. Claims 7, 9, and 10 are allowable over the Cornwell and Ackerman references for the reasons discussed in reference to their parent claim, claim 4. The Aoki reference remedies none of the deficiencies of the Cornwell and Ackerman references. These claims are thus also allowable over the art of record.

Conclusion

For the foregoing reasons, Applicant believes all the pending claims are in condition for allowance and should be passed to issue. If the Examiner feels that a telephone conference would in any way expedite the prosecution of the application, please do not hesitate to call the undersigned at (408) 446-8694.

Respectfully submitted,

Dan H. Lang

Dan H. Lang
Reg. No. 38,531

RITTER, LANG & KAPLAN LLP
12930 Saratoga Ave., Suite D1
Saratoga, CA 95070
Tel: 408-446-8690
Fax: 408-446-8691

VERSION WITH MARKINGS TO SHOW CHANGES MADE TO THE APPLICATION

In the Specification

Please replace the paragraph beginning on page 9, line 3, with the following:

Fig. 2 is a graph depicting the relationship between four-wave mixing-induced cross-talk and forward Raman gain according to one embodiment of the present invention. The theoretical basis for the data determined in Fig. 2 may be found in [U.S. Provisional App. No. 60/279,854, entitled INTERACTION OF FOUR-WAVE MIXING AND DISTRIBUTED RAMAN ARCHITECTURE and filed on March 28, 2001] the included appendix. Fig. 2 is a useful tool in selecting values for G_F and G_B. The x axis of the graph of Fig. 2 represents unsaturated forward Raman gain. The left y-scale of the graph of Fig. 2 represents input power per channel to fiber 115. The right y-scale of Fig. 2 reports the corresponding four-wave mixing-induced cross talk at the end of the whole link of 25 spans assuming that G_B provides the remainder of the 15 dB that G_F does not provide. To get this crosstalk, individual contributions from each span are added.

Please replace the paragraph beginning on page 11, line 23, with the following:

Fig. 4 shows the [Raman] Rayleigh backscattering product caused by either the co-propagating pump or counter-propagating pump. This product is computed using the techniques disclosed in P.Hansen et al., *IEEE Photon. Tech. Lett.*, Vol.10, No1 (1998), p. 159, the contents of which are herein incorporated by reference. To evaluate the backscattering product suppression for a given configuration of Raman amplifier 113, one separately determines the suppression levels for the forward and backward gains using the values given by Fig. 4 for the number of spans in the link. Then, the double Rayleigh back scattering noise levels contributed by the forward and backward gain are computed given the suppression levels and the signal level at the output level of Raman amplifier 113. These noise levels are added and compared to the signal level to obtain the double Rayleigh backscattering suppression level. In general, double Rayleigh backscattering suppression of greater than 30 dB is typically required. For our previous example system where G_F= 5.5 dB and G_B= 9.5 dB, the double Rayleigh backsckattering suppression is approximately 37.5 dB.

In the Claims

Please replace the pending claims with the following:

1. (Cancelled)

2. (Amended) [The apparatus of claim 1] In an optical communication system, apparatus for amplifying an optical signal, said apparatus comprising:

a fiber; and

an optical pump energy source disposed to inject optical pump energy into said fiber in a co-propagating direction relative to a transmission direction of an optical signal in said fiber to cause Raman amplification of said signal in accordance with a gain level; and

wherein said gain level is greater than 4 dB; and

wherein either 1) [given] for a selected signal to noise ratio, there is a greater four-wave mixing product suppression level than would be achieved using only a counter-propagating optical pump energy source to obtain said gain level or 2) [given] for a selected four-wave mixing product suppression level, there is a higher signal to noise ratio than would be achieved using only said counter-propagating energy source to obtain said gain level.

3. (Cancelled).

4. (Amended) [The apparatus of claim 3] In an optical communication system, apparatus for amplifying an optical signal, said apparatus comprising:

a first optical pump energy source disposed to inject optical pump energy into a fiber in a co-propagating direction relative to a transmission direction of said optical signal to cause Raman amplification of said signal in accordance with a first gain level;

a second optical pump energy source disposed to inject optical pump energy into said fiber in a counter-propagating direction relative to said transmission direction of said optical signal to cause Raman amplification of said signal in accordance with a second gain level, said optical signal experiencing a total gain level including said first gain level and said second gain level; and

wherein said first gain level is greater than 4 dB wherein either 1) for [given] a selected signal to noise ratio, there is a greater four-wave mixing product suppression level than would be achieved using only said second optical pump energy source to obtain said total gain level or 2) for [given] a selected four-wave mixing product suppression level, there is a higher signal to noise ratio than would be achieved using only said second optical pump energy source to obtain said total gain level.

5. (Amended) The apparatus of claim [3] 4 wherein said first gain level is set responsive to a minimum tolerable four-wave mixing product suppression level and a desired signal to noise ratio.

6. The apparatus of claim 5 wherein said first gain level is also set responsive to a maximum tolerable saturation level.

7. The apparatus of claim 5 wherein said second gain level is set responsive to said first gain level and said total gain level.

8. (Cancelled).

9. (Amended) The apparatus of claim [3] 4 wherein a power level of said first optical pump energy source is set responsive to said first gain level.

10. (Amended) The apparatus of claim [3] 4 wherein a power level of said second optical pump energy source is set responsive to said second gain level.

11. (Amended) The apparatus of claim [3] 4 further comprising said fiber.

12. (Amended) The apparatus of claim [3] 4 further comprising:

an Erbium-doped fiber amplifier in cascade with said fiber.

13. (Cancelled).

14. (Cancelled).

15. (Amended) [The apparatus of claim 13] In an optical communication system, apparatus for amplifying an optical signal, said apparatus comprising:

a first optical pump energy source disposed to inject optical pump energy into a fiber in a co-propagating direction relative to a transmission direction of said optical signal to cause Raman amplification of said signal; and

a second optical pump energy source disposed to inject optical pump energy into said fiber in a counter-propagating direction relative to said transmission direction of said optical signal to cause Raman amplification of said signal; and

wherein said first gain level is greater than 4 dB; and

wherein either 1) for [given] a selected signal to noise ratio at an output of said fiber, there is a greater four-wave mixing product suppression level achieved than would be achieved using only said second optical pump energy source to achieve said desired gain level or 2) for [given] a selected four-wave mixing product level at an output of said fiber, there is a higher signal to noise ratio than would be achieved using only said second optical pump energy source to achieve said desired gain level.

16. (Amended) The apparatus of claim [13] 14 further comprising said fiber.

17. The apparatus of claim 16 further comprising an Erbium-doped fiber amplifier in cascade with said fiber.

18. (Cancelled).

19. (Amended) [The method of claim 18] In an optical communication system, a method for amplifying an optical signal within a fiber by exploiting Raman effects to achieve a desired gain level, said method comprising:

injecting co-propagating optical pump energy into said fiber to cause Raman amplification according to a first gain level;

injecting counter-propagating optical pump energy into said fiber to cause Raman amplification according to a second gain level; and

wherein said first gain level is greater than 4 dB; and

wherein either 1) for [given] a selected signal to noise ratio at an output of said fiber, there is a greater four-wave mixing product suppression level than would be achieved injecting only said counter-propagating optical pump energy to obtain said desired gain level or 2) for [given] a selected four-wave mixing product level, there is a higher signal to noise ratio than would be achieved using injecting only said counter-propagating optical energy to obtain said desired gain level.

20. (Amended) The method of claim [18] 19 wherein injecting co-propagating optical pump energy comprises injecting co-propagating optical energy at a power level set responsive to a minimum tolerable four-wave mixing product suppression level and a desired signal to noise ratio.

21. The method of claim 20 wherein said power level is also set responsive to a maximum tolerable saturation level.

22. The method of claim 20 further comprising:
further amplifying said signal within an Erbium-doped fiber amplifier.

23. (Cancelled)

24. (Amended) [The apparatus of claim 23] In an optical communication system, apparatus for amplifying an optical signal within a fiber by exploiting Raman effects to achieve a desired gain level, said method comprising:

means for injecting co-propagating optical pump energy into said fiber to cause Raman amplification;

means for injecting counter-propagating optical pump energy into said fiber to cause Raman amplification according to a second gain level; and

wherein said first gain level is greater than 4 dB; and

wherein either 1) for [given] a selected signal to noise ratio at an output of said fiber, there is a greater four-wave mixing product suppression level than would be achieved injecting only said counter-propagating optical pump energy to obtain said desired gain level or 2) for [given] a selected four-wave mixing product level, there is a higher signal to noise ratio than would be achieved injecting only counter-propagating optical energy to obtain said desired gain level.

25. (Amended) The apparatus of claim [23] 24 wherein said means for injecting co-propagating optical pump energy comprises means for injecting co-propagating optical energy at a power level set responsive to a minimum tolerable four-wave mixing product suppression level and a desired signal to noise ratio.

26. (Amended) The apparatus of claim [23] 24 wherein said power level is also set responsive to a maximum tolerable saturation level.

27. (Amended) The apparatus of claim [23] 24 further comprising:
means for further amplifying said signal within an Erbium-doped fiber amplifier.